Irrigation Management Measures to Improve the Quality of Runoff Water

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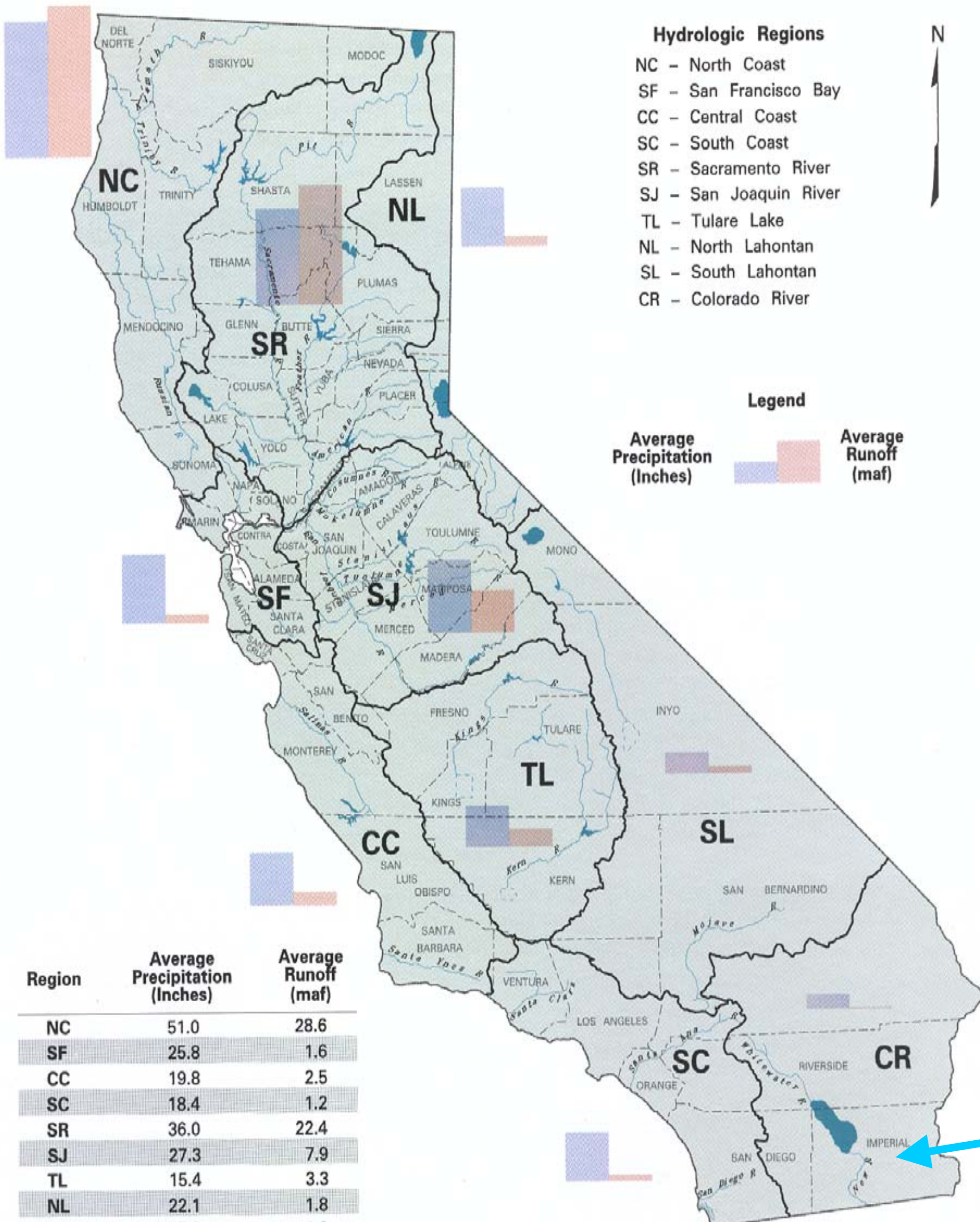
University of California Cooperative Extension-

UC Desert Research & Extension Center

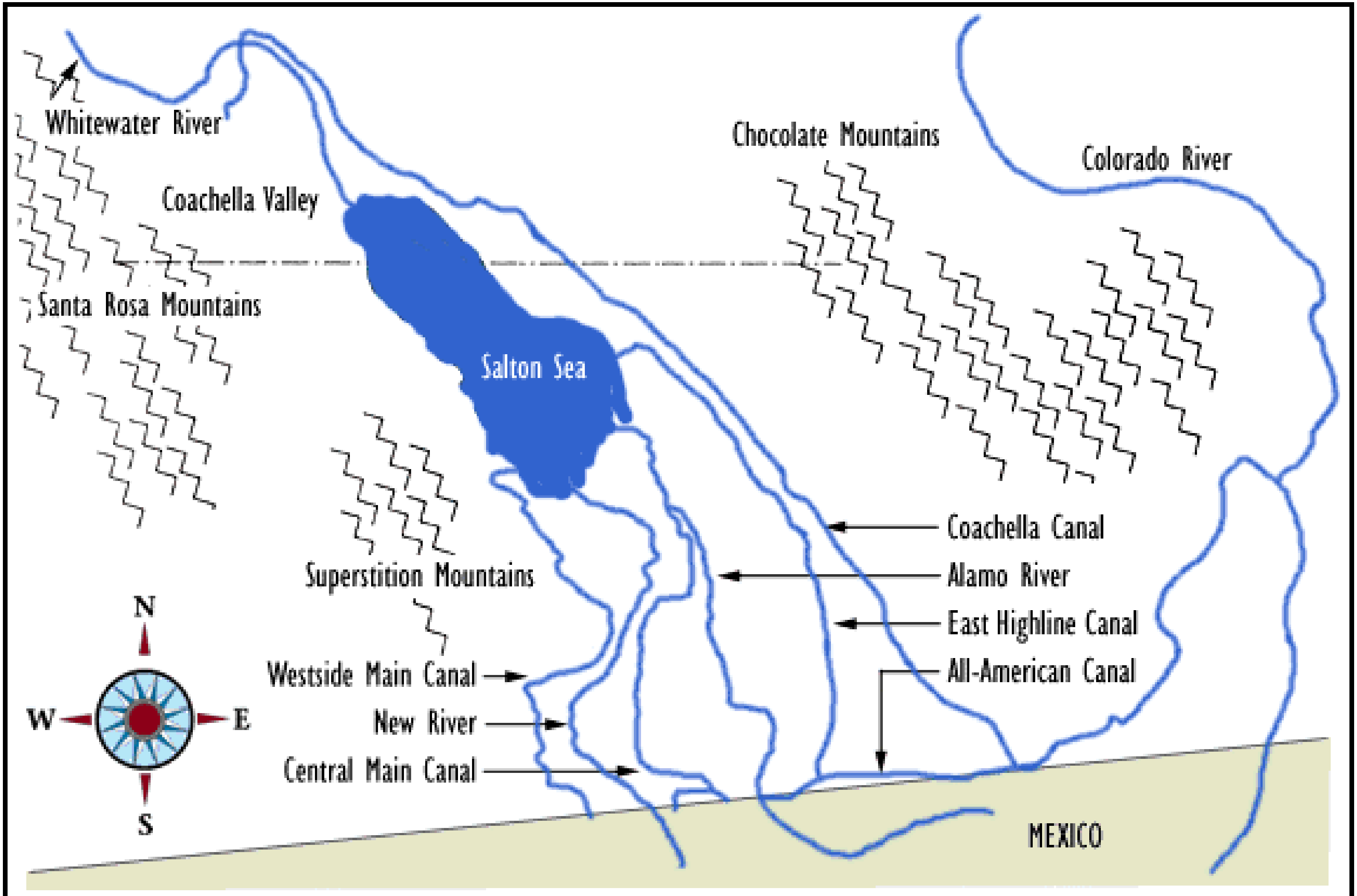
Third Biennial NPS Conference
Measuring Water Quality Improvements
Sacramento, Nov 7-9, 2005



Region	Average Precipitation (Inches)	Average Runoff (maf)
NC	51.0	28.6
SF	25.8	1.6
CC	19.8	2.5
SC	18.4	1.2
SR	36.0	22.4
SJ	27.3	7.9
TL	15.4	3.3
NL	22.1	1.8
SL	7.9	1.3
CR	5.5	0.2
Entire State	22.9	70.8

Imperial Valley
(CRWQCB-R7)

Map of the Salton Sea Area



Imperial Valley

- Irrigated area: ~ 450,000-500,000 acres

- Average water use:~ 6 ac-ft/ac per year

- Irrigation water: ~2.6-3.0 MAF/year

- Surface Irrigation: ~ 95% of irrigated area

- Surface & subsurface drainage: ~30-35%

- Ag. Flow to Salton Sea ~1.1-1.2 MAF/year

Salton Sea Watershed

Impaired Water Bodies- 303(d) list

- New River (60 miles)
  (85-90% drainage from irrigated agriculture)
- Alamo River (52 miles)
  (95-98% irrigated agriculture)
- Imperial Valley drains (1,305 miles)
- Salton Sea (220,000 acres)
  (>95% irrigated agriculture)
- Palo Verde Outfall drains (16 miles)
- Coachella Valley Stormwater Channel (20 miles)

TMDL standards

- Sediment/silt TMDL- Rivers & Agricultural Drains in Region 7

~ 400 mg/L (objectives ~50% reduction)

- Nutrient (P) TMDL- Salton Sea:

Substantial reduction in P load is needed?

Realistic objective (25-50% reduction) ?

TMDL ??% reduction

The impact of suspended sediment on water quality and ecosystem (drains and rivers)

Direct impact

- Clog fish gills
- Prevent the development of fish egg and larvae
- Interfere fish migration
- Reduce food abundance by (i) smothering bottom-dwelling organisms and (ii) reducing light penetration (thus photosynthesis)

Indirect impact

- Transport of pesticides (e.g. fish and birds)
- Transport nutrients (P & N)

P and Eutrophication

- Phosphorus was identified as limiting agent in eutrophication of the Salton Sea
- Eutrophication: at P conc. as low as 0.02 mg/L
- Phosphorus reaches waterways: adsorbed or soluble
- Silt TMDL identified BMTs for reducing adsorbed phosphorus
- Nutrient TMDL will focus on both adsorbed and soluble phosphorus

Salton Sea (1999): 0.005-0.222 mg/L

median in surface water 0.071 mg/L

Alamo River (1999): 0.719 mg/L (agricultural drains)

New River (1999):1.11 mg/L (agricultural drains + Mexicali)

Salton Sea Nutrient TMDL- P

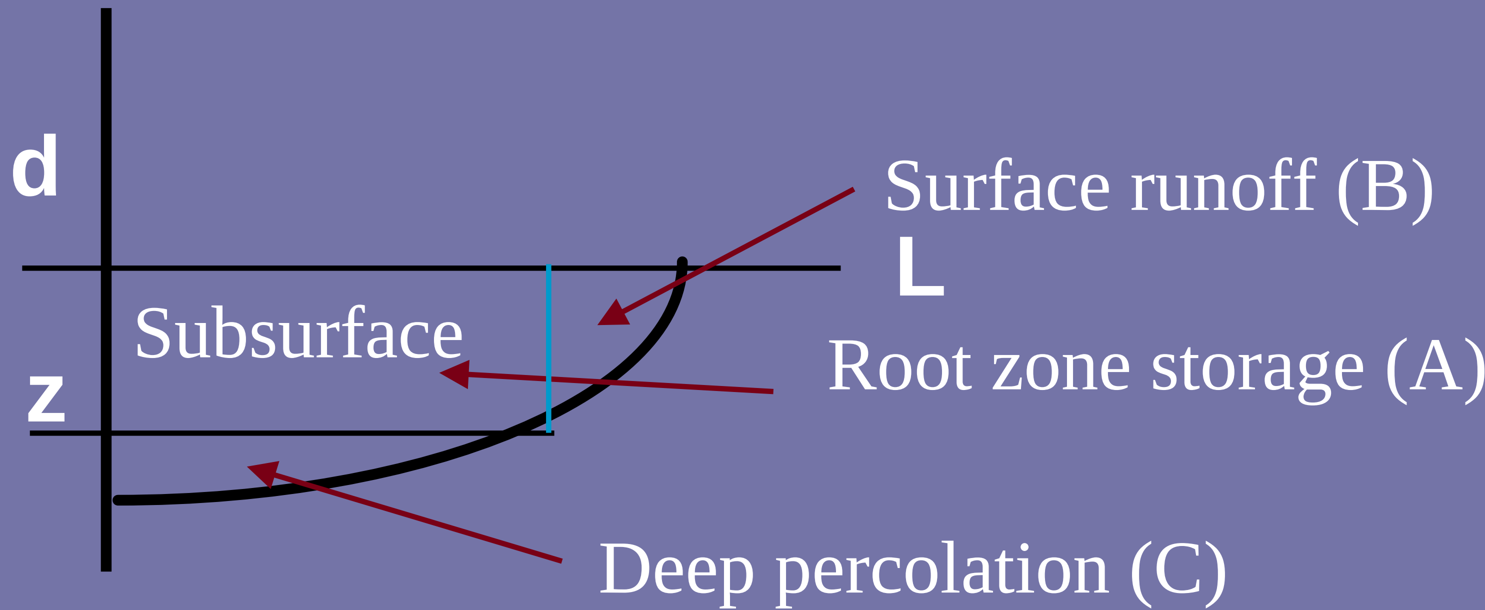
TMDL Objective: Reduction in P loading rate

External ($1.34*10^6$ kg/yr)
(~80% ag. ~500,000 ac)
~ 5 lb P/ac per year (~11 lb P_2O_5 /ha)

P application rates: 100-250 lb/ac (P_2O_5)

Surface Irrigation

Applied water = Root zone storage + runoff + deep percolation



$$\text{Application Efficiency (AE)} = \frac{A}{(A+B+C)}$$

Irrigation methods:

Surface irrigation (flood):

- Border (flat) irrigation

P losses: Soluble P in runoff water & soil erosion

Runoff rate: 5-20%

- Furrow (bed) irrigation

P losses: Soil erosion, soluble P in runoff water

Runoff rate: 15-30%

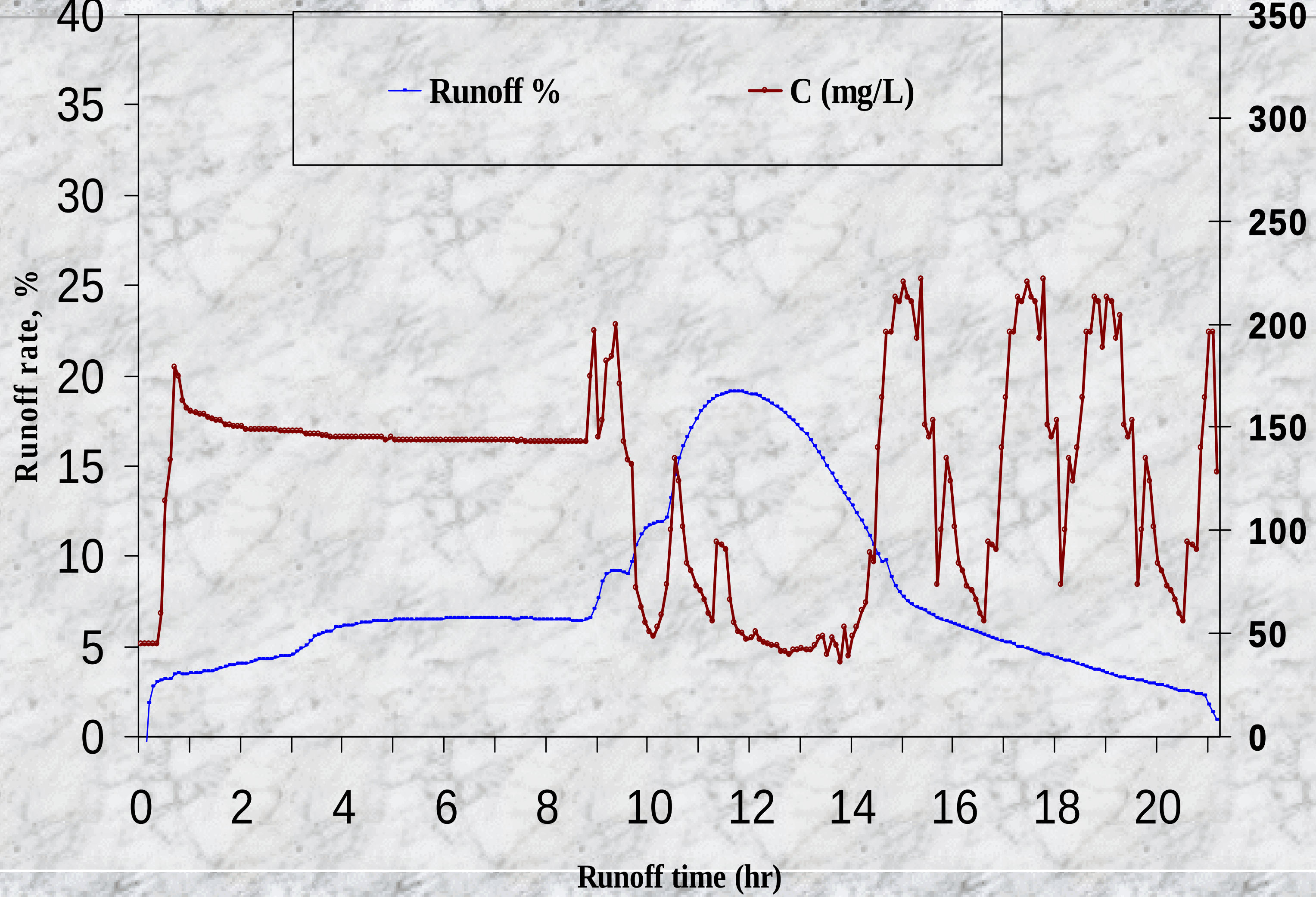
Average surface runoff: 17%

Agriculture in the Imperial Valley:

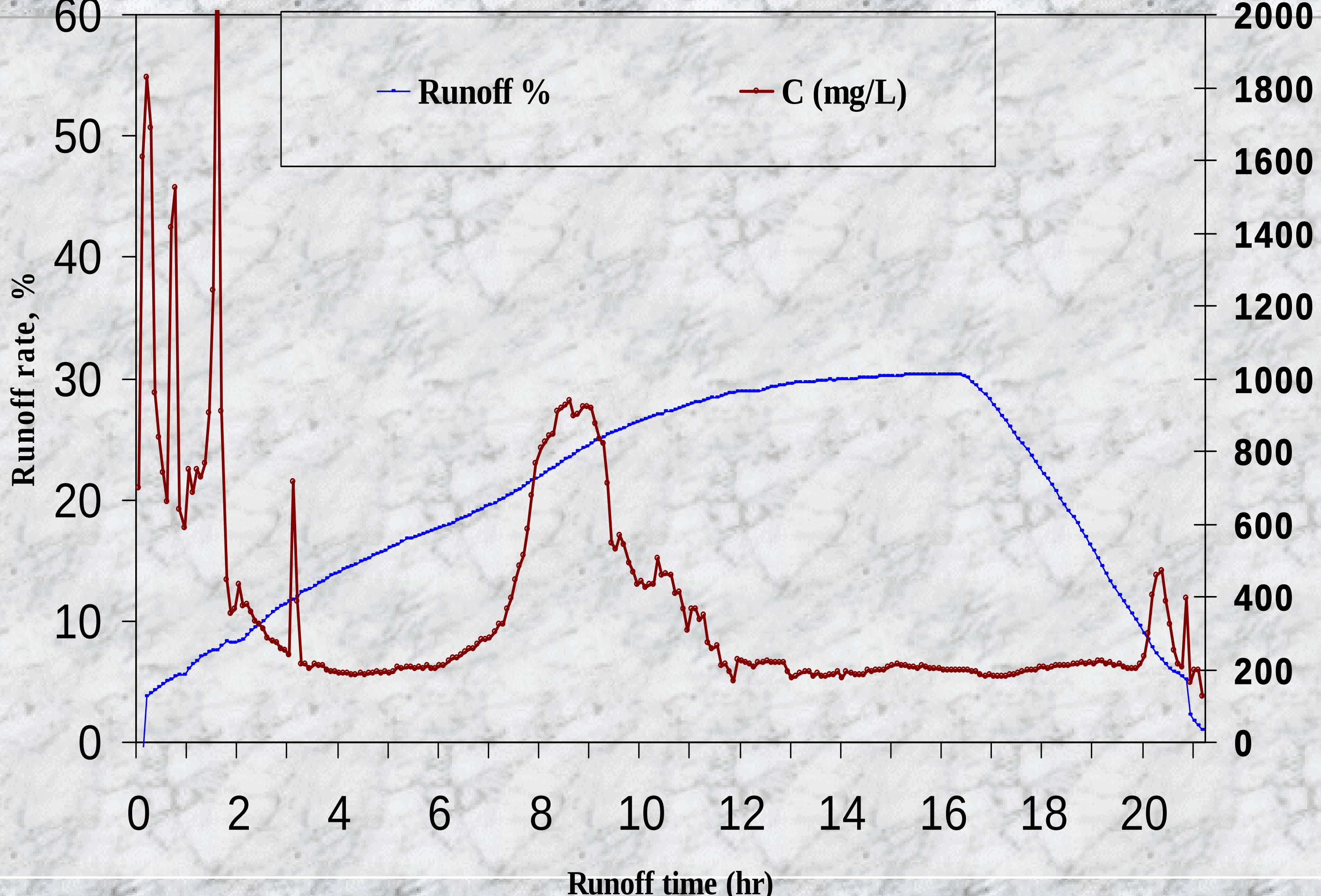
	Acres
Field Crops	**400,000**
Vegetable & Melon Crops	**90,000**
Fruit & Nut Crops Crops	**7,000**
Seed & Nursery Crops	**65,000**

Source: 1995-2003 Imperial County Agricultural Crop & Livestock report

Field A (Alfalfa, Border, May 2005, UCDREC)



Field B (Alfalfa, Furrow, May 2005, UCDREC)



Best Management Techniques (BMTs) for Phosphorus & Sediment Control in Drainage Waters

- BMTs are methods, measures, or practices selected by agencies, districts, growers, etc to meet point and/or nonpoint source control objectives.
- BMTs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters.

Nutrient Management

- Selecting the proper time, placement and method of fertilizer (phosphorus) application to reduce losses through soil erosion, and ensure adequate crop nutrition

Management practices to achieve Sediment and P-TMDL objectives

A) On-Farm practices (sediment & P)

B) Watershed/subwatershed practices (P & sediment)

C) Salton Sea (P)

D) Source control from Mexicali (P)

Practices

- Minimize/eliminate Runoff or Tailwater
- Filter Tailwater
- Recycle Tailwater

On-Farm BMTs for Minimizing Tailwater

- Irrigation Water Management
- Landleveling
- Nutrient Management
- Infiltration Additive (PAM)

Irrigation Water Management

- Determining and controlling the rate, amount, and timing of irrigation water applied to crops to minimize phosphorus movement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Irrigation Landleveling

- Reshaping the surface of land to planned grades to give effective and efficient water movement

Infiltration Additive (PAM)

Control

PAM-10 ppm


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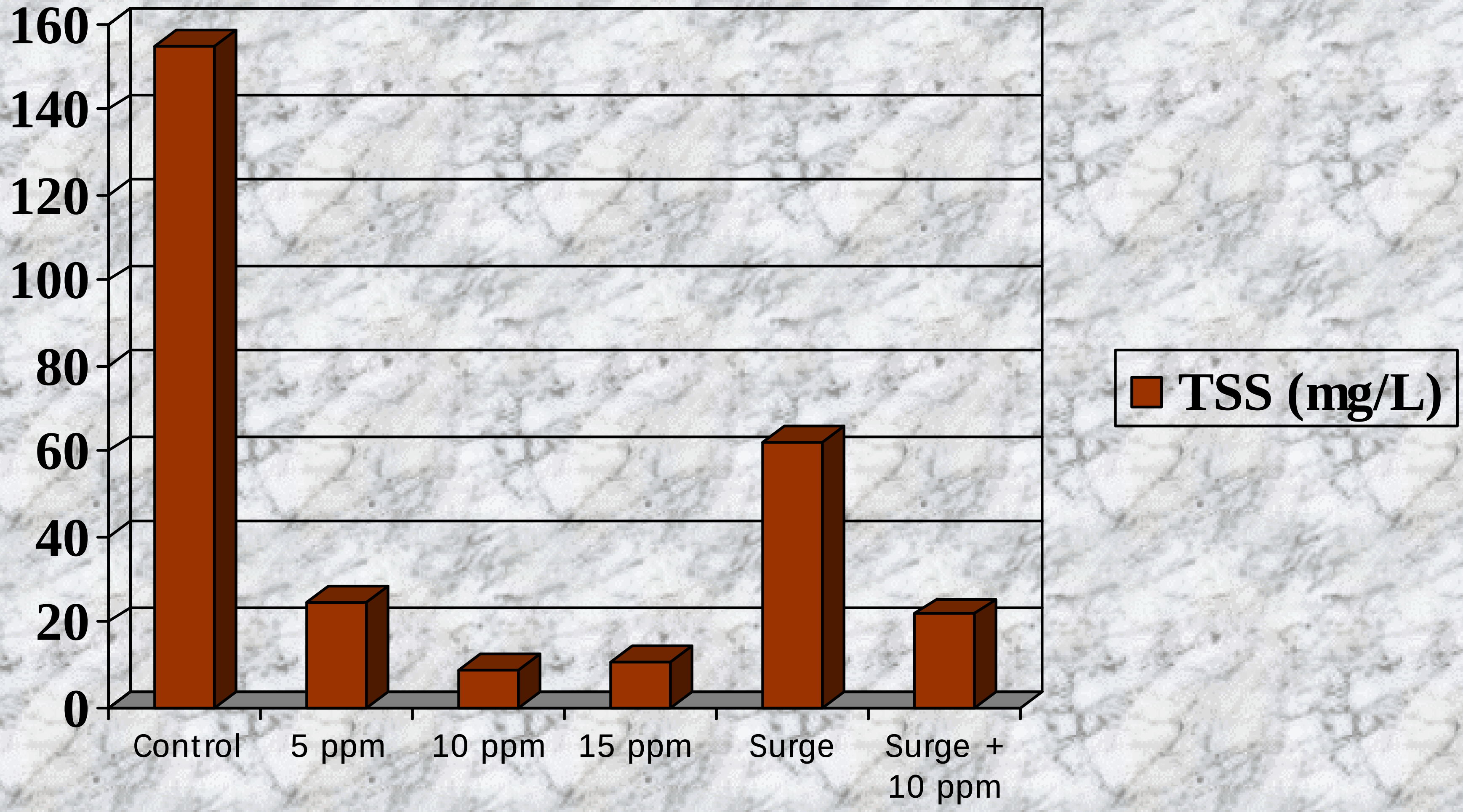
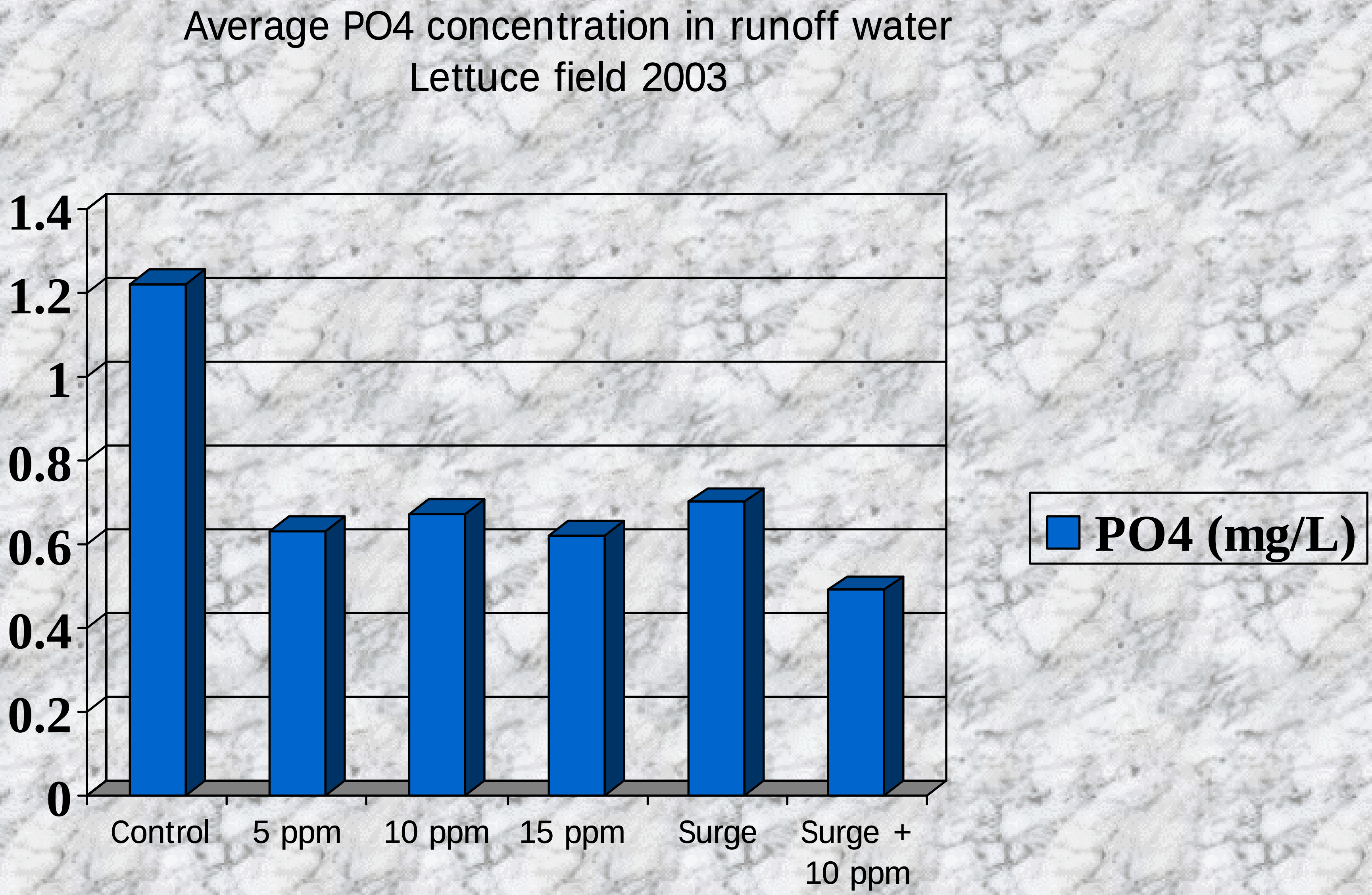
Average sediment load in runoff water
Lettuce field 2003




Average PO4 concentration in runoff water
Lettuce field 2003
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Control
5 ppm
10 ppm
15 ppm
Surge
Surge + 10 ppm
PO4 (mg/L)

BMT's for Filtering Tailwater

- Grassed Waterway
- Filter Strips
- Natural or Constructed Wetlands (surface & subsurface)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BMT's for Recycling Tailwater

- Irrigation System, Tailwater Recovery

Tailwater Recovery

- Regulating the type and quantity of water return flows as a means of maintaining and improving irrigation water quality


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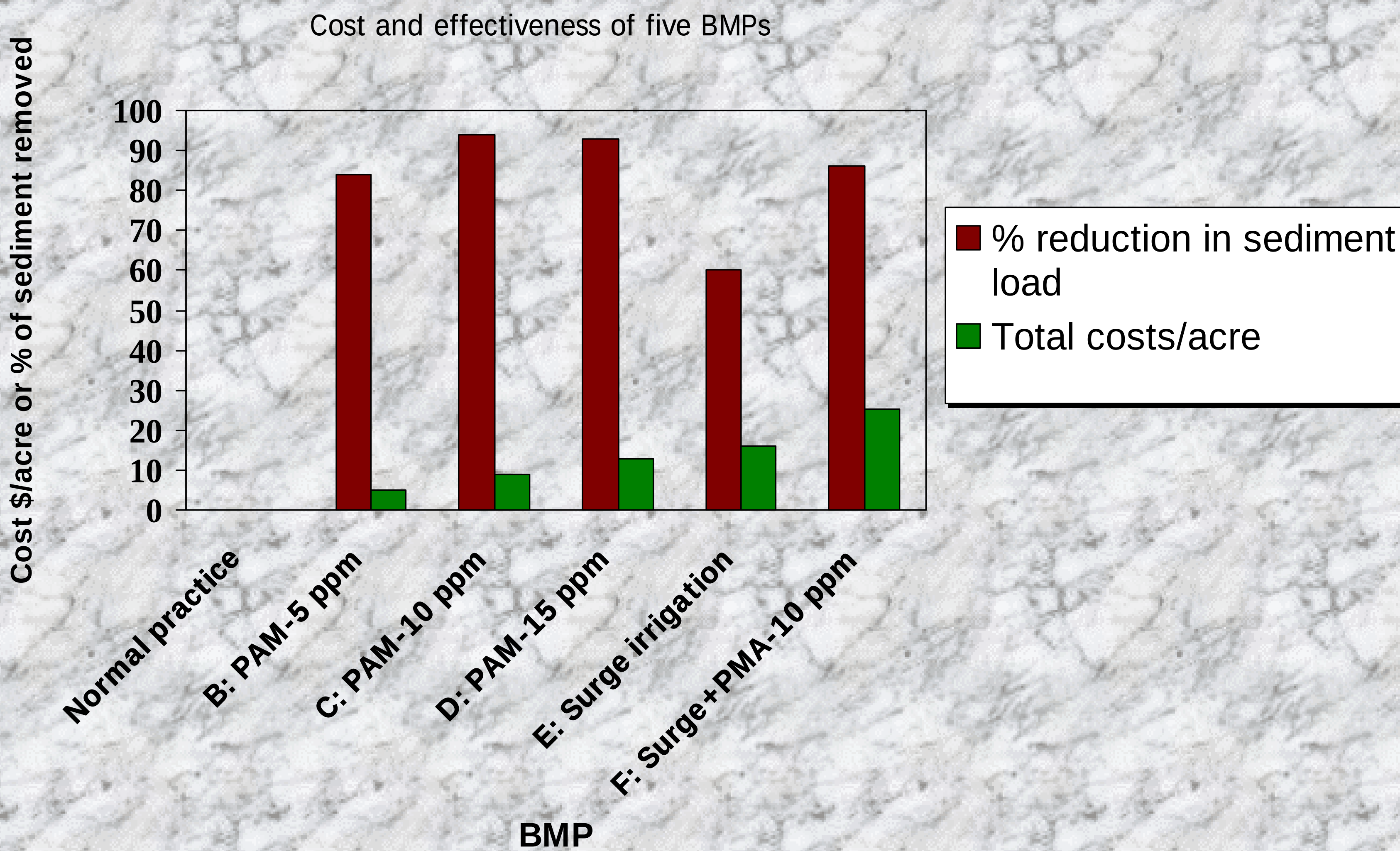
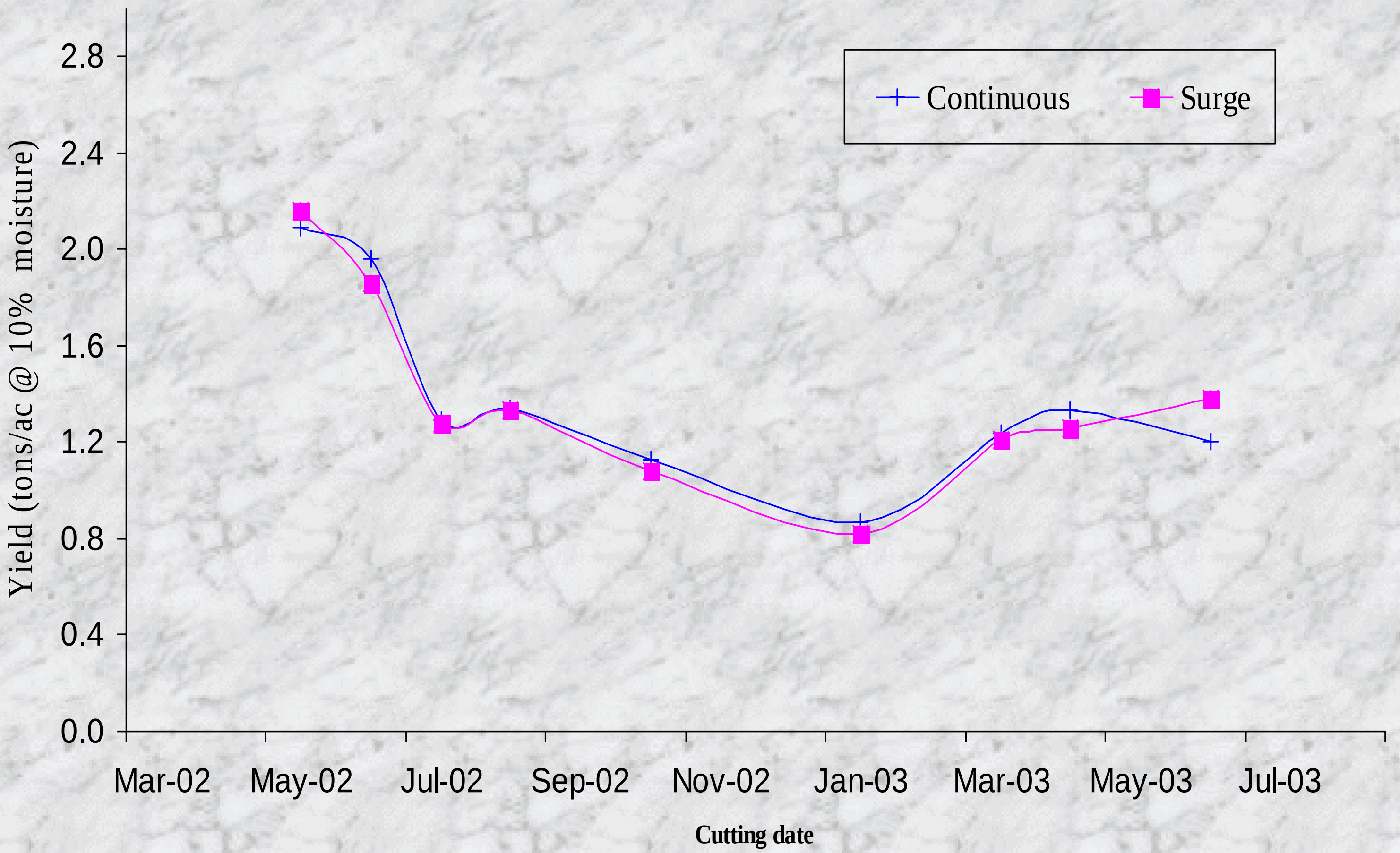
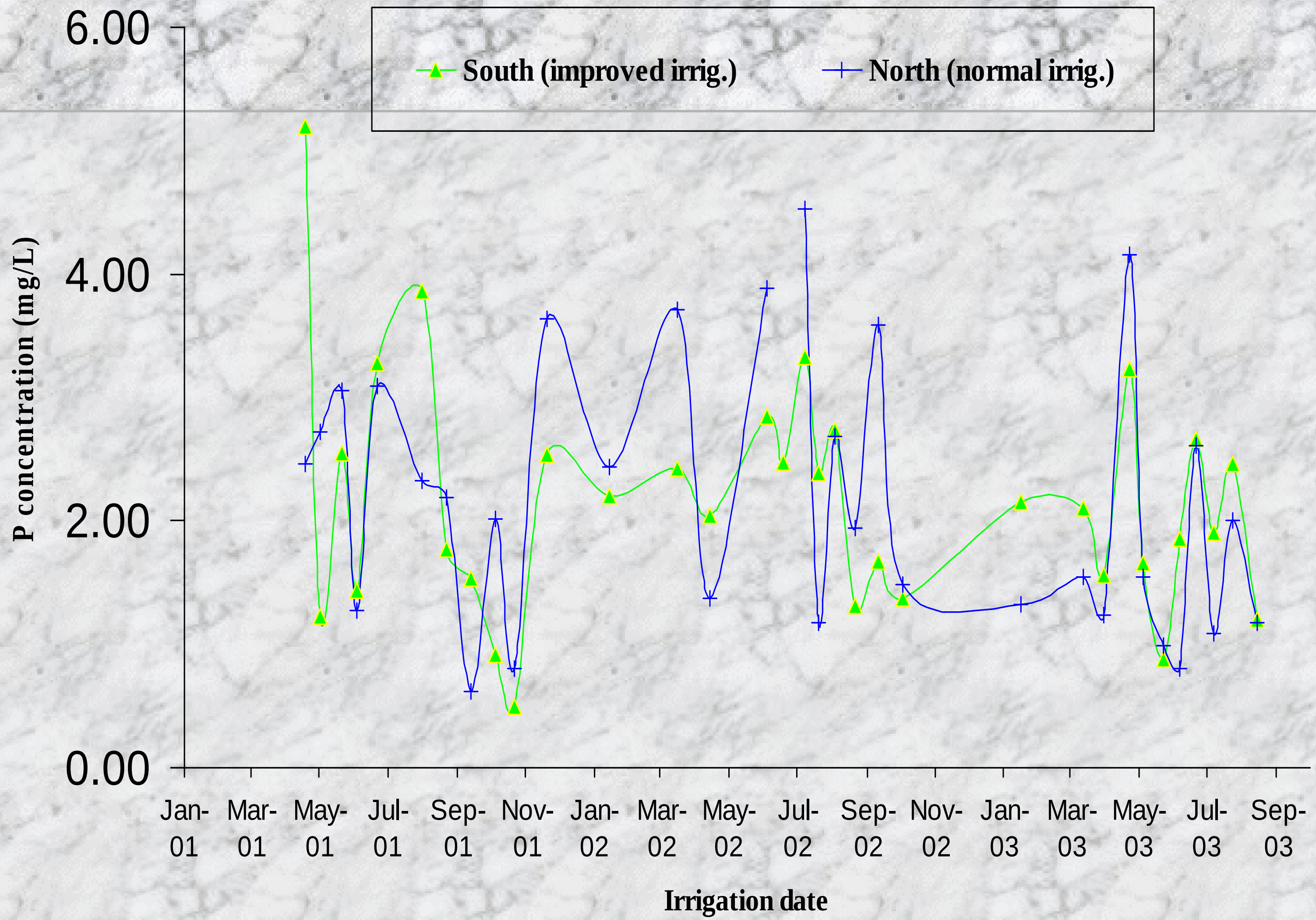


Cost and effectiveness of five BMPs
Cost $/acre or % of sediment removed
100
90
80
70
60
50
40
30
20
10
0
Normal practice
B: PAM-5 ppm
C: PAM-10 ppm
D: PAM-15 ppm
E: Surge irrigation
F: Surge+PMA-10 ppm
BMP
% reduction in sediment load
Total costs/acre

Figure 1. Alfalfa yield per treatment Area 60-UCDREC



P concentration in runoff water (mg/L)



Management practices to achieve Sediment and P-TMDL objectives

A) On-Farm practices (sediment & P)

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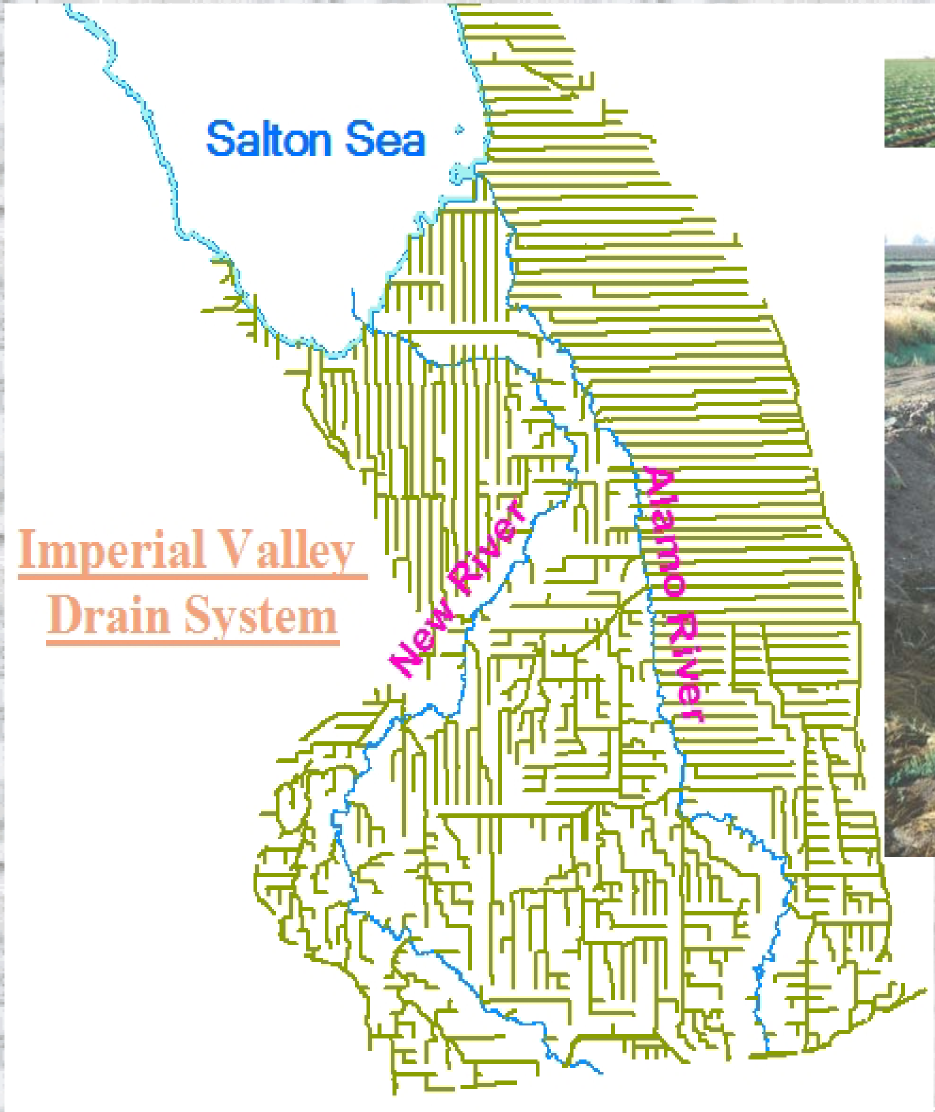
C) Salton Sea (P)

D) Source control from Mexicali (P)

Drainage system



Sediment transport at smaller temporal scales

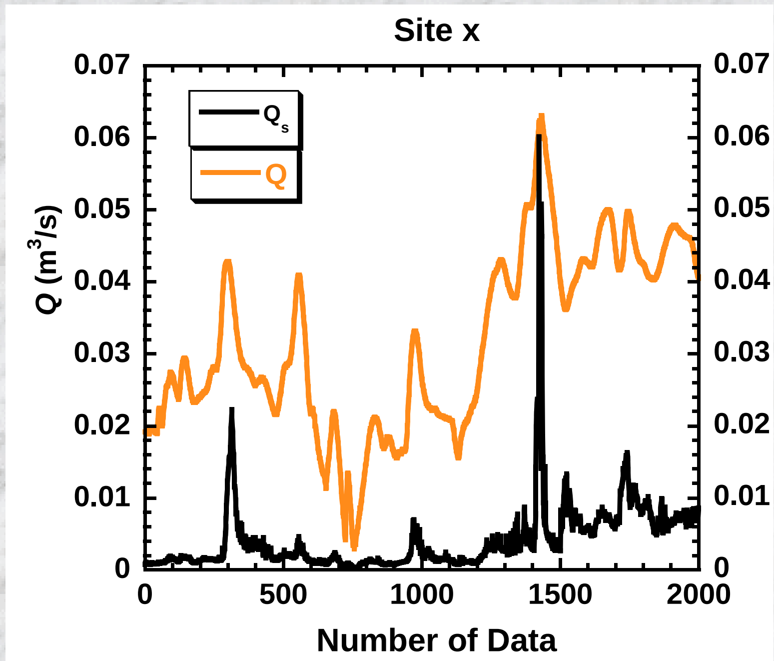
Effect of temporal and spatial scales on sediment transport:

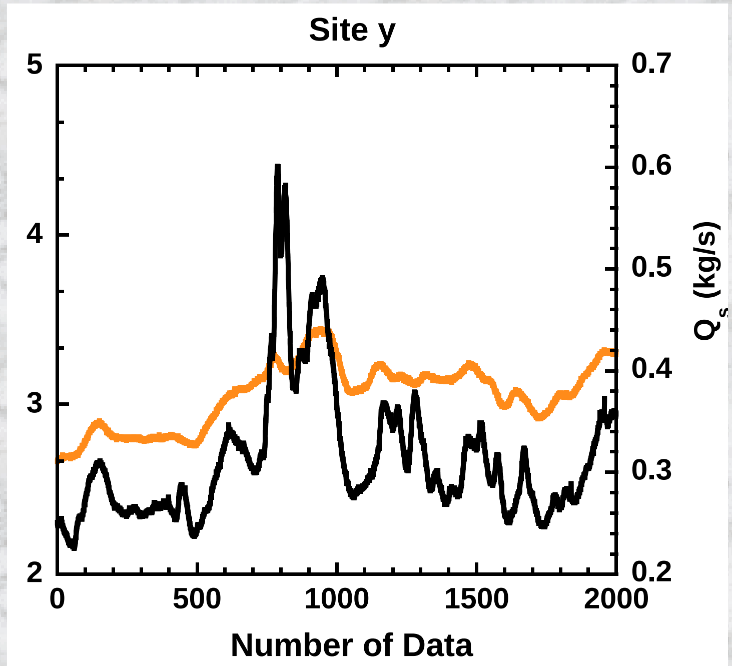
	Site x		Site y	
	Sed. Load(kg)	Duration (min)	Sed. Load(kg)	Duration (min)
Two highest Peaks (I)	10.095	570	721.2	1740
Total Data (II)	40.74	10,000	3135.3	10,000
Percentage of (I) in (II)	25%	5.7%	23%	17.4%

At smaller spatial scales, sediment is deposited on the channel beds at a short period of time with a large magnitude and then is eroded for a longer time with a small magnitude until next deposition occurred

Sediment transport at smaller temporal scales

Effect of temporal scales on sediment transport (1):

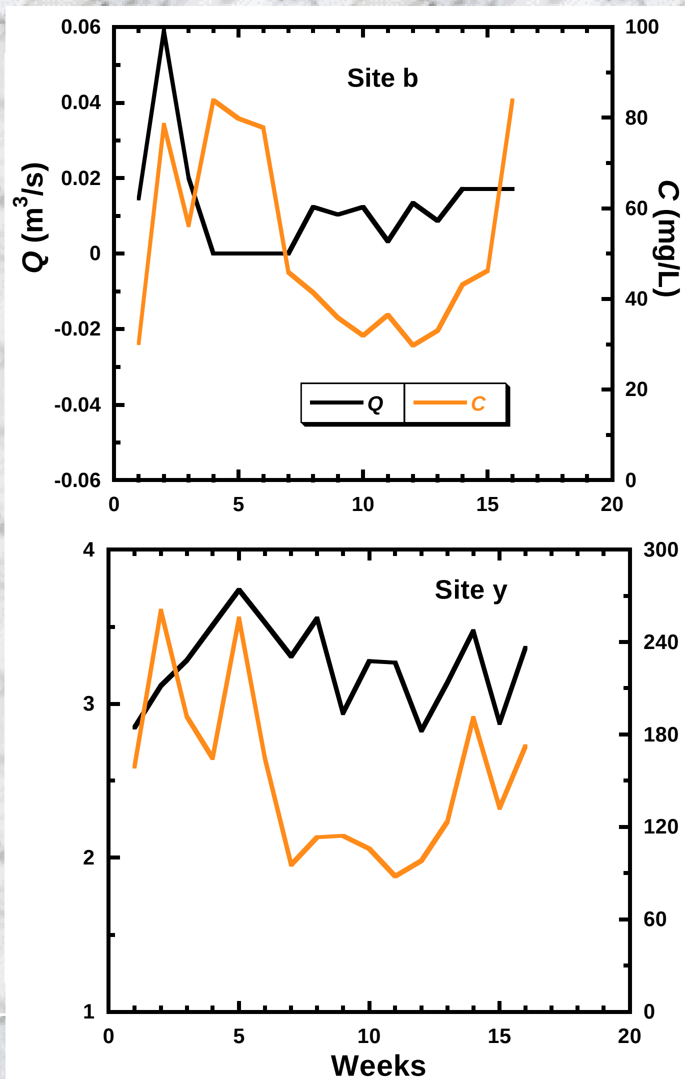


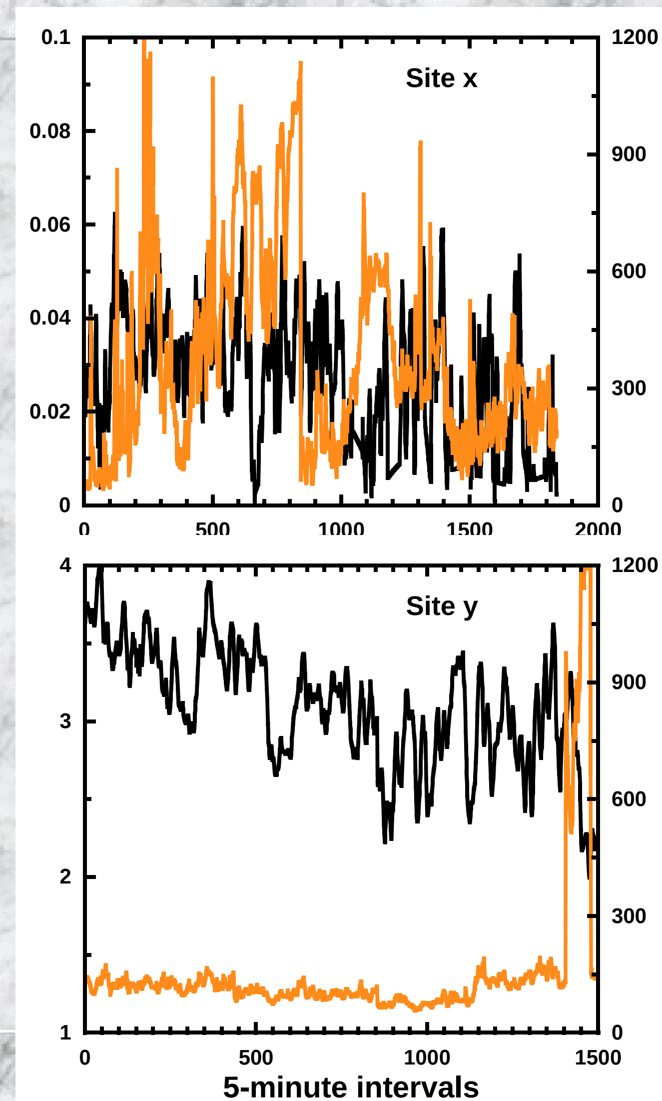


Considerable Q and Q_s variations occurred within one week period

Results (Cont.)

Data variation with both space and time:

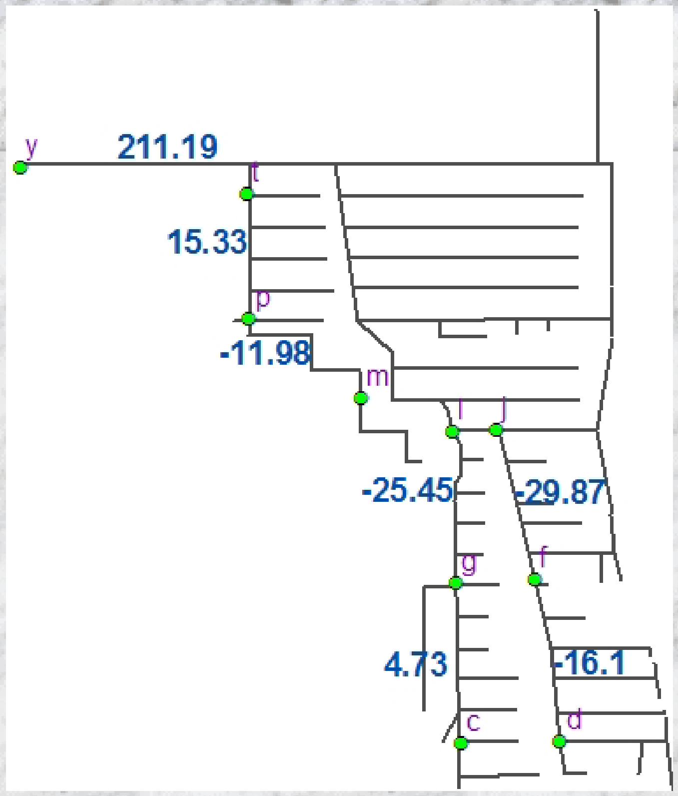




A sediment model at larger temporal scales

Mass balance analysis:

Channel reaches along the three channels	Mass balance results	
	Q_{net} (t/wk)	Fluvial process
Between “m” and “p”	-11.98	Erosion
Between “p” and “t”	15.33	Deposition
Between “c” and “g”	4.73	Deposition
Between “g” and “l”	-25.45	Erosion
Between “d” and “f”	-16.10	Erosion
Between “f” and “j”	-29.87	Erosion
Between “l” and “y”	211.19	Deposition



Deposition and erosion processes do not show any spatial pattern

Sediment

- Samples at large temporal scales (weekly data)

Can accurately characterize erosion and deposition (E/D) processes at larger spatial scale but not at smaller spatial scale

- Samples at smaller temporal scales (5-minute interval data)

Can correctly describe E/D processes at smaller spatial scales

The overall sediment transport process (i.e. DEPOSION) is described by samples from multiple spatial and temporal scales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Natural or Constructed Wetlands

- Providing adequate land absorption or wetland areas downstream from agricultural areas so that soil and plants receive and treat agricultural nonpoint source pollutants


Thank You

Questions?

Effectiveness of BMTs on Surface Water Quality

Technique	Efficacy
Irrigation Water Management	L-M
Landleveling	Negligible
Infiltration Additive (PAM)	M-H *
Nutrient Management	L-H
Grassed Waterway	L
Filter Strips	M
Field Border	Negligible
Natural or Constructed Wetlands	H
Irrigation System, Tailwater Recovery	L-H

L = Low efficacy

M = Low to moderate efficacy

H = Moderate to high efficacy

* Not obtained from FOTG

Cost of BMTs

Technique	Cost
Irrigation Water Management	$15 per acre per year
Landleveling	N/A
Infiltration Additive (PAM)	$1.50 per acre per irrigation *
Nutrient Management	Varying
Grassed Waterway	Installation - $0.05-0.05 per foot O & M - $0.03-0.15 per acre per year
Filter Strips	Installation - $0.04 per foot for 30-foot-wide strip O & M - $0.04-0.25 per foot
Field Border	N/A
Natural or Constructed Wetlands	Constructed Treatment Wetlands - $35,000-150,000 per acre **
Irrigation System, Tailwater Recovery	Installation - $300-500 per acre O&M - $28-60 per acre per year

* Lentz et al, 1992

** www.bnl.gov/erd/peconic/Wetlands.pdf

Farmer John

Bound			
initial application	100lbs/acre P	43.7lbs P/acre	*
Plant uptake		41.6 lbs P/acre	*
P lost in sediment	2.1 lbs P/acre		
Silt TMDL Compliant			
Silt TMDL (50%) reduction	1.05 lbs P/acre		
* Adapted from Bali, 4/24/02			

Farmer John

water run irrigation		
Mass Applied	125 lbs H3PO3	47.25 lbs P/ acre
%bound in soil	90%	
%in surface water	9%	
%in subsurface drainage	1%	
mass bound in soil (lb P/acre)	42.52	
mass in surface water (lb P/acre)	4.25	
mass in subsurface drainage (lb P/acre)	0.47	

Farmer John with BMTs

Nutrient TMDL Compliant				
Practice	%reduction	~mass reduced in surface water	~mass reduced by Silt TMDL	Total Phosphorus reduction
Nutrient Management	20-80	0.85-3.4 lb P/acre	1.05 lb P/ acre	1.90-4.45 lb P/acre
Irrigation Water Management	20-60	0.85-2.5 lb P/acre	1.05 lb P/ acre	1.90-3.55 lb P/acre
Infiltration Additive (PAM)	40-80	1.7-3.4 lb P/acre	1.05 lb P/ acre	2.75-4.45 lb P/acre
Grassed Waterway	20-40	0.85-1.7 lb P/acre	1.05 lb P/ acre	1.90-2.75 lb P/acre
Filter Strip	40-60	1.7-2.5 lb P/acre	1.05 lb P/ acre	2.75-3.55 lb P/acre
Natural or Constructed Wetland	80	3.4 lb P/acre	1.05 lb P/ acre	4.45 lb P/acre
Irrigation System, Tailwater Recovery	20-80	0.85-3.4 lb P/acre	1.05 lb P/ acre	1.90-4.45 lb P/acre


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Grassed Waterway

- Establishing and maintaining adequate plant cover on channel banks to stabilize channel banks

Filter Strips

- A strip or area of vegetation in permanent vegetation, established downslope of agricultural runoff or waste water source to control erosion, reduce organic matter, and other pollutants from entering an adjacent watercourse


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